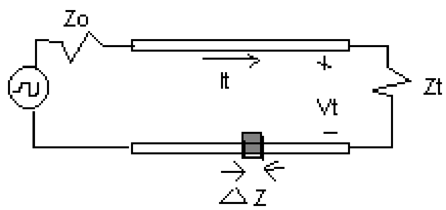
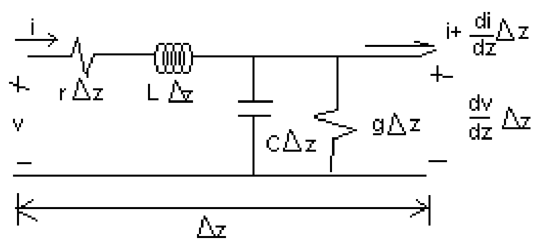
ECE 5340/6340 APPLICATION OF FDFD TO TRANSMISSION LINE IMPEDANCE

Transmission line theory:





- Can't use Lumped element approach because wavelength is approx. size of the FDFD element.
- Use incremental approach instead

$$Zo = \sqrt{\frac{L}{C}} = \sqrt{\frac{LCo}{CCo}} = \frac{1}{V_{po}\sqrt{CCo}}$$

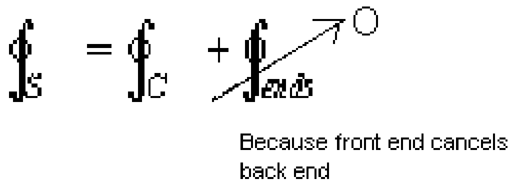
$$V_p = \frac{1}{\sqrt{LC}} = V_{po}\sqrt{\frac{Co}{C}}$$

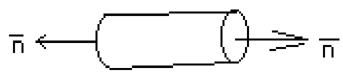
$$V_{po} = \frac{1}{\sqrt{L_o C_o}} = 2.996e8 m/s$$

For TL in free space V_p=V_{po}.
Co = Capacitance/unit length of TL without dielectric
C = Capacitance/unit length of TL with dielectric
TO CALCULTE CAPACITANCE from numerical simulation:

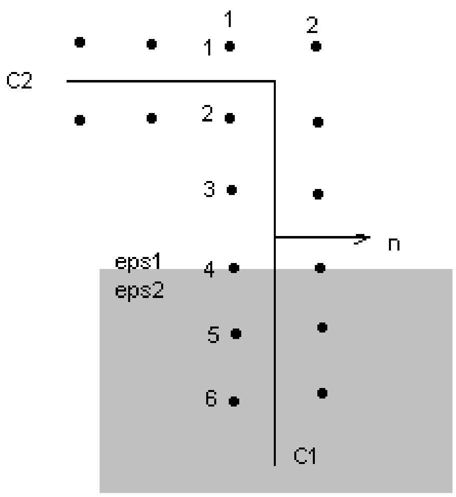
$$C = q/V$$

$$q = \int_S \varepsilon.\overline{E} \bullet d\overline{S} = \int_S \varepsilon(-\nabla\phi) \bullet d\overline{S} = \int_S \varepsilon\left(\frac{-d\phi}{dn}\right)dS$$





Use Numerical differentiation and integration:
$dV/dn = (V_{n+1} + V_n) / dn$
trapezoidal integration = h [f(a)/2 + f(b)/2 + sum(f)]



$dV/dn = (Vj,2 - Vj,1)/h_x$

$$\oint_{C1} \varepsilon \frac{\partial \phi}{\partial n} \bullet dl_1 = h_y \left\{ \begin{array}{l} \varepsilon_1 \left[\frac{\phi_{21} - \phi_{11}}{h_x} + \frac{\phi_{22} - \phi_{12}}{h_x} + \frac{\phi_{23} - \phi_{13}}{h_x} \right] \\ + \left(\frac{\varepsilon_1 + \varepsilon_2}{2} \right) \left[\frac{\phi_{24} - \phi_{14}}{h_x} \right] + \varepsilon_2 \left[\frac{\phi_{25} - \phi_{15}}{h_x} + \frac{\phi_{26} - \phi_{16}}{h_x} \right] \end{array} \right\}$$

METHOD TO FIND characteristic impedance Zo:
1) Simulate Microstripline (complete, with two dielectrics)
    a) Find potential (phi) distribution
    b) Integrate 4 line integrals around the top conductor to find charge on top conductor. (May use symmetry.)
    c) Find Q1 and C1
2) Simulation Microstripline (air ONLY, no dielectrics)
    a) Find potential (phi distribution)
    b) Integrate 4 line integrals around the top conductor

to find charge on top conductor. (May use symmetry.)

a) Find Qo and Co

3) Calculate V_p and Zo:

$V_p = V_o \sqrt{}\,(Co/C)$

$Zo = 1/\,(V_{po} \sqrt{}(C\ Co))$